Michigan State University
East Lansing, Michigan 48824

USE OF REMOTE SENSING FOR LAND USE POLICY FORMULATION

Annual Progress Report, December 1977 - November 1978

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Scope of Report

This document reports the remote sensing research and service activities carried out during the 1977-78 grant year from December 1, 1977 through November 30, 1978 by a team of faculty investigators and a staff of research specialists and assistants within the Remote Sensing Project of Michigan State University. It is a continuation of the Semi-Annual Progress Report, dated March 14, 1978 which covered the period June 1, 1977 through November 30, 1977.

A C K N O W L E D G E M E N T S

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I N T R O D U C T I O N

Issues of land, water and related resource use, misuse, and debilitation continue as a high priority area of urban concern for environmental viability of Michigan and the United States. Action programs are required for remedying accumulated abuses and mismanagements; for preserving and conserving the environmental resource qualities remaining. Effective programs can only be formulated by a broad community of scientific disciplines and by the energies and actions of many public and private institutions. A prerequisite to the formulation and acceptance of any effective action program is the ready availability of accurate and timely information for the forumlation of policies which can be quickly translated into combinations of short-term and long-range remedial and preventative programs. Remote sensing is now becoming recognized and acknowledged as a major technological means for providing this kind of information. This MSU Project has played a major role in bringing this change about in Michigan.

The primary objective of the Project is to work with all levels of government in Michigan, plus private concerns, to develop a wide diversity of applications of remote sensing for improved land/resource use decisions and actions. In following this objective, Project activities are aimed at improving, across the board, the process of analyzing and allocating land and resource use in Michigan, and eventually developing a responsible and self-supporting community of users of remote sensing in the State. To accomplish these aims, Project staff conduct demonstration applications of

A. RESEARCH APPLICATIONS

The five units of research application contained in this section comprise a variety of studies concerning issues stemming from actions for eliminating some environmental hazards, for identifying areas of special ecological value for appropriate preservation/conservation, for providing biomass information for an experimental energy program, and in modifying the natural resource base for some structural purposes.

Remote sensing was judged to be a means for acquiring crucial information and realizing analyses which could not be achieved as quickly, reliably, and of recent date. Some information, perhaps, could not be acquired at all by any other means.

The research units selected and reported herein were selected as ones for which program implementation for improvements in environmental status would likely be instituted by early actions.

Some of these applications initially demanded considerable Project input. When rendered operational, these were gradually transferred to appropriate agencies for continuation or development to more advanced stages which would lead to subsequent actions. Others are expected to return to command Project attention from time to time when new information might be determinable or when additional decisions will need to be made regarding on-land applications.

remote sensing, provide user services, and participate in educational activities.

The following presentation describes in summary fashion the principal activities engaged during the December 1, 1977 to November 31, 1978 period. For reporting purposes, the activities were grouped under three broad headings: (A) Research Applications; (B) User Services; and (C) Contractual Services.

A. Mosquito Control in Saginaw and Bay Counties

Saginaw-Bay Mosquito Control Commission (SBMCC)
1816 South River Road
Bay City, Michigan 48706

Information on forested wetlands and residential areas in Saginaw and Bay Counties, derived from remotely-sensed data and reported in the last semi-annual status report (June 1977 - November 1977), has been used by the Saginaw-Bay Mosquito Control Commission (SBMCC) to prioritize treatment areas and formulate operational strategies for the control of early season Aedes mosquitoes in the Spring of 1978.

Standardized county maps depicting areas of seasonally flooded woodlots (1:175,000 scale) were modified to provide an estimate of the total flooded area and location by township. The procedure consisted of enlarging each township to a scale of approximately 1:45,600 and then transcribing the interpreted data on individually flooded woodlots to a separate 9" x 12" sheet. Each site was measured for area using a compensating polar planimeter. Map scales for individual 9" x 12" sheets were calculated using one section line (1 mile) as a reference for ground distance. The vernier units and section numbers (utilized to determine locations within each township) were calculated and recorded next to each site. Finally total area of flooded woodland in each township was computed and a cumulative county acreage tabulated (Table 1.).

Further refinement was undertaken to clearly delineate flooded woodlands that were in close proximity with population centers. Since early

TABLE 1.--Total Acreage by Township of Forested Wetlands in the Saginaw-Bay Mosquito Control District as Determined by Remote Sensing.

SAGINAW COUNTY		BAY COUNTY	
Township	Flooded Woods (acres)	Township	Flooded Woods (acres)
Buena Vista	57.30	Beaver	1013.30
Zilwaukee	57.30	Fraser	524.70
Spaulding	522.40	Garfield	2258.80
Saginaw	137.00	Mt. Forest	2633.60
Kochville	31.86	Gibson	1029.10
Swan Creek	538.40	Kawkawlin	925.90
Thomas	347.30	Williams	482.40
Tittabawassee	144.20	Monitor	270.80
Fremont	256.30	Frankenlust	97.10
Richland	143.80	Portsmouth	12.95
Lakefield	375.90	Bangor	46.10
Jonesfield	120.10	Hampton	103.70
Blumfield	134.30	Merritt	54.20
Frankenmuth	64.00	Pinconning	772.40
Birch Run	441.50	Total Acres	10225.05
Bridgeport	388.70		
Taymouth	434.80		
Albee	278.60		
Maple Grove	236.60		
Chesaning	128.60		
St. Charles	317.80		
Brady	344.00		
Brant	1192.50		
Chapin	995.30		
Marion	1483.00		
Total Acres	9556.76		

season Aedes mosquitoes do not have extensive migration ranges, it was decided that a two-mile perimeter be established around populated areas (Fig. 1). This would insure maximum control in suburban areas which have continual problems with woodland pool mosquitoes. All sites within each perimeter area were tabulated and a cumulative figure for acreage by township was calculated (Table 2).

A system of prioritized zones was developed in order to rank each area sequentially for chemical larvacide treatment (Fig. 1). Priority was dependent upon population density and total acreage of flooded woodlots. Finally a zip code designation was given to each treatment zone enabling acquired data to be stored in the SBMCC computer system.

The Priority 1 Area contains approximately 75% of the population for the counties. Since it has been shown that the environmental risk is greatest in urban areas with high population, these areas rate the highest priority. In this area the prime consideration is the possibility of epidemics of mosquito-borne St. Louis encephalitis (SLE), particularly as documented disease activity in the 1975 SLE epidemic suggested that the risk is highest in urban environments. The most effective method of disease control for the SLE vector is a combination of larviciding and adulticiding with emphasis on the former. An extensive catch basin larviciding program must be undertaken to significantly suppress the vector population.

Priority 2 Areas are basically suburban population clusters. Population densities are not as high, but these areas still warrant surveillance. The mosquito-borne disease risk is primarily California encephalitis (CAL) in subdivisions and to a lesser degree SLE in settlements that have catch basin systems.

TABLE 2.--Total Acreage by Township of Forested Wetlands Located Within a Two-Mile Perimeter Around Population Centers.

SAGINAW COUNTY		BAY COUNTY	
Township	Acres	Township	Acres
Buena Vista	0.00	Beaver	0.00
Zilwaukee	57.30	Fraser	352.10
Spaulding	215.70	Garfield	0.00
Saginaw	140.20	Mt. Forest	0.00
Kochville	31.86	Gibson	0.00
Swan Creek	379.10	Kawkawlin	832.00
Thomas	298.10	Williams	427.30
Tittabawassee	104.80	Monitor	270.80
Fremont	69.60	Frankenlust	71.20
Richland	110.40	Portsmouth	12.95
Lakefield	41.80	Bangor	46.10
Jonesfield	111.50	Hampton	35.50
Blumfield	0.00	Merritt	33.90
Frankenmuth	20.20	Pinconning	326.00
Birch Run	70.80	Total Acres	2407.85
Bridgeport	312.20		
Taymouth	171.90		
Albee	50.00		
Maple Grove	0.00		
Chesaning	103.60		
St. Charles	223.20		
Brady	95.00		
Brant	116.50		
Chapin	0.00		
Marion	0.00		
Total Acres	2723.76		

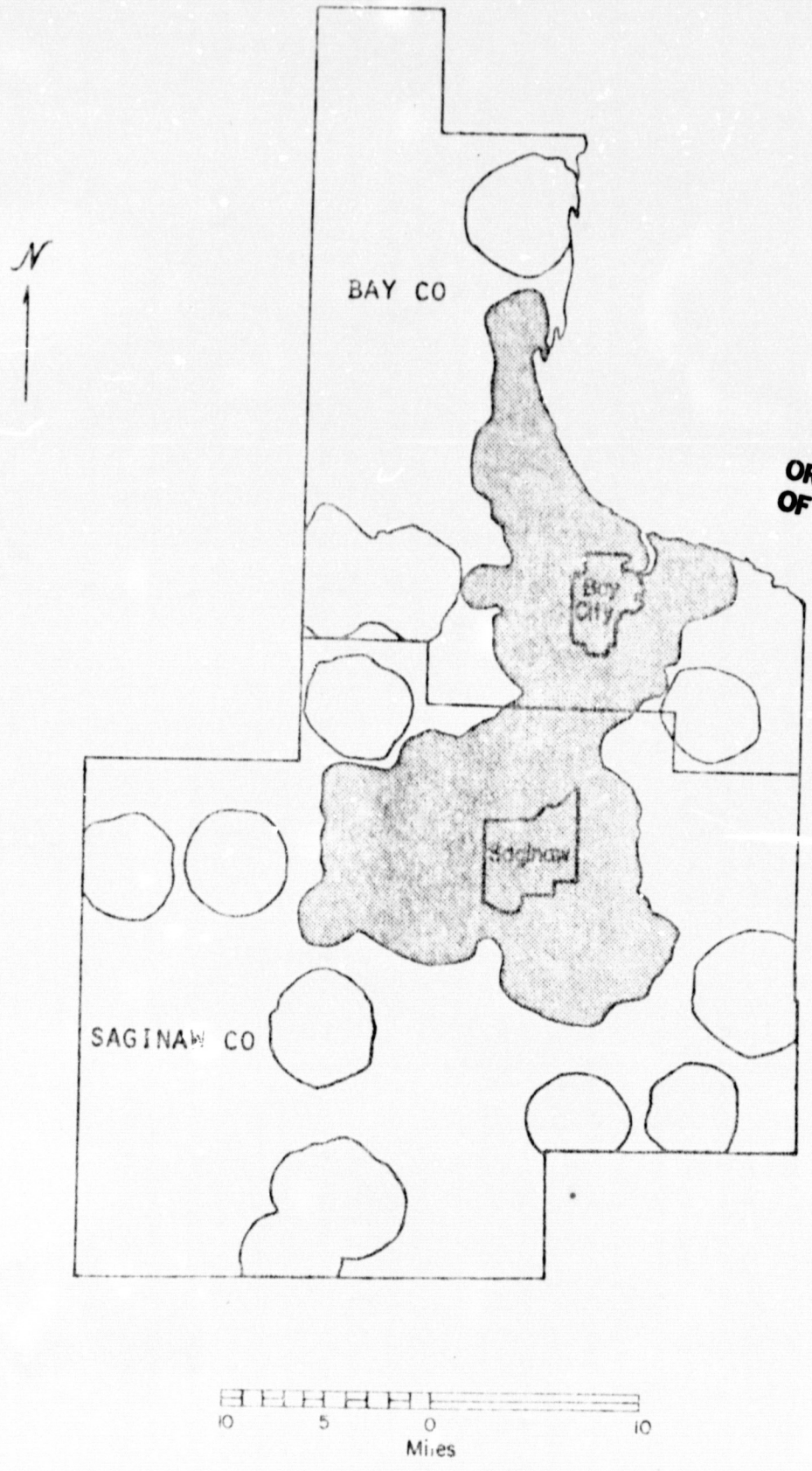


Figure 1.--Saginaw-Bay Mosquito Control Commission Priority Areas.

Routine surveillance will be conducted in these areas with resultant chemical treatment (larviciding, adulticiding) being undertaken if vector density warrants. Requests for mosquito control from the public will supplement routine surveillance and control.

Priority 3 Areas contain less than 5% of the total population and disease probability is not significant to suggest routine surveillance. The control method is basically an adulticiding operation in response to requests from the public.

The resultant prioritized system was utilized in the following manner. Each Priority Area was given a color code and the zip codes within each area assigned their respective color. The zip codes and corresponding colors were transferred to standard County Highway maps to clearly identify areas requiring maximum effort in mosquito and mosquito-borne disease surveillance and control. Also each zip code with the respective age cohorts were entered into a data matrix created for the SBMCC's IBM 5100 computer system. The matrix has been and will be further enlarged with biological data to update the informational base on specific mosquito infestations and vector-borne disease activity.

The plans to develop township maps using a more detailed classification scheme outlined in the last reporting period were abandoned and an inventory of wet areas within the forested portions of Priority Areas 1 and was subsequently provided to SBMCC. The 1975 NASA imagery was updated using April 1978 color-infrared photography acquired in 35mm format from a light plane. The information was transferred to plat book maps to facilitate easy field use by treatment teams. Initial evaluation of these

procedures indicate their utility in the identification of breeding sites for Aedes mosquitoes.

The development of a computer-based information and analysis system is progressing. Table 3 lists potential elements identified to date and indicates those elements that can be derived from remote sensing sources:

Table 3.--Potential Elements of a Geographic Information System Oriented Toward Mosquito Control.

***	1.	Habitat Type
***	2.	Habitat Area
***	3.	Length of Drains (Channelization)
	4.	Climatological Data (Temperature, Precipitation)
	5.	Soils (Texture, Water-holding Capacity)
	6.	Physiography (Slope, Aspect, Elevation)
	7.	Population Structure
***	8.	Settlement Pattern (Housing Density, Spacing)
***	9.	Outdoor Public Assembly (Recreation, Meeting Places)
	10.	Employment Characteristics (Exposure Potential)
***	11.	Access Parameters (Distance Variables)
	12.	Mosquito Counts (Species Distribution)
	13.	Infection Rates
	14.	Treatment Type(s)
	15.	Problem Areas Identified by the Public (Telephone Complaints)
	16.	Animal Host Survey Information
	17.	Avian Host Survey Information

The Resource Analysis Program (RAP) developed by the Remote Sensing Project will allow analysis of the data matrix being created on the IBM 5100 computer

system by the SBMCC. Zip code and population structure information have been entered into the data matrix. The matrix will be further enlarged with biological data to update the informational base on specific mosquito infestations and vector-borne disease activity.

Richard Hill-Rowley represented the Remote Sensing Project at the American Mosquito Control Association meetings in Chicago, Illinois in April 1978 and presented a paper entitled, "Utilization of Remote Sensing by Local Mosquito Control Agencies" in conjunction with staff members from the SBMCC.

A2. Identification of Wild Areas in Southern Lower Michigan

Wilderness and Natural Areas Program
Michigan Department of Natural Resources
Stevens T. Mason Building
Lansing, Michigan 48909

Michigan House Bill No. 4881, the "Wilderness and Natural Areas Act," authorizes the state, through the Department of Natural Resources (DNR), to create and regulate tracts of undeveloped land and water, to be known as "wild areas," for natural preservation. The DNR requested the assistance of the Remote Sensing Project in developing an inventory methodology for identification of these wild areas using primarily remote sensing data sources. Criteria established in this procedure were tested in six counties of southern lower Michigan which represent a wide range of terrain types and the specific characteristics of this work are described in the last semi-annual report (June 1977 - November 1977).

Since that report, the Wild Area Criteria list has been revised to more concisely represent important environmental characteristics of potential sites (Table 4) and in conjunction with this, a detailed grading scheme assigning point values to each division of wild area criteria has been established. The individual point values assigned to the specific characteristics of each identified wild area were summed to determine a final numerical value for each area. Table 5 lists the cumulative point value for each of the 57 wild areas identified in the six-county study area.

TABLE 4.--Wild Area Criteria for Michigan.

I. AREA
- A. 80-319 acres
- B. 320-639 acres
- C. 640-1279 acres
- D. 1280-2999 acres

II. TOPOGRAPHY
- A. Local Relief
  - 1. 0-49'
  - 2. 50-99'
  - 3. 100-199'
  - 4. 200-399'
  - 5. 400-699'
  - 6. 700' or more
- B. Maximum Slope
  - 1. 0-6%
  - 2. 6-12%
  - 3. 12-18%
  - 4. 18%+

III. SOILS
- A. Predominant Drainage
  - 1. Poorly Drained
  - 2. Somewhat Poorly Drained
  - 3. Well Drained
- B. Predominant Texture
  - 1. Organic
  - 2. Sand
  - 3. Clay
  - 4. Loam

IV. LANDFORM TYPE
- A. Glacial
  - 1. Lacustrine Plain
  - 2. Outwash Plain
  - 3. Ground Moraine (Till Plain)
  - 4. End Moraine
  - 5. Esker
  - 6. Drumlin
  - 7. Kame
  - 8. Other Stagnation Features
- B. Fluvial
  - 1. Floodplain
  - 2. Delta
  - 3. Stream Terraces
  - 4. Cliff, Bluff, Scarp
  - 5. Stream Cut Valleys or Gorges
  - 6. Other
- C. Wave Action
  - 1. Beach Ridges
  - 2. Spits, Sand Bars
  - 3. Bluff, Cliff, Scarp
  - 4. Other
- D. Eolian
  - 1. Sand Dune
  - 2. Other
- E. Karst
  - 1. Sinkhole
  - 2. Cave
  - 3. Other
- F. Rock Outcrop

V. VEGETATION
- A. Type
- B. Composition
  - 1. % Broadleaf Forest
  - 2. % Coniferous Forest
  - 3. % Rangeland (Shrubs & Grasses)
- C. Maturity

VI. HYDROGRAPHY
- A. Density
  - 1. Wetlands
    - a. 0-10%
    - b. 11-30%
    - c. 31-75%
  - 2. Open Water and Streams
    - a. <1%
    - b. 1-40%
    - c. 41-75%
- B. Water Features
  - 1. Open Water
    - a. Pond (<5 acres)
    - b. Lake (≥5 acres)
  - 2. Stream
    - a. Channel Width >50'
    - b. Channel Width <10'
    - c. Channel Width 10'-50'
  - 3. Swamp/Marsh
  - 4. Bog
  - 5. Springs
  - 6. Rapids
  - 7. Waterfalls

VII. LOCATION
- A. Distance in Kilometers from Population Centers (100,000 or more)
- B. Breakdown by Surface Types
  - 1. 4-lane Limited Access
  - 2. 4-lane Highway
  - 3. 2-lane Paved
  - 4. Improved (gravel, stone)
- C. Estimated Travel Time

VIII. HUMAN INFLUENCE
- A. Cultural
- B. Historical
- C. Habitat Modifications

IX. PERIPHERAL LAND USE
- A. Natural Cover
- B. Land Use

Table 5.--Cumulative Point Value for Identified Wild Areas by County.
(Note: Those underlined have been field-checked.)

WILD AREA	ALLEGAN	BAY	BRANCH	IONIA	LIVINGSTON	ST. CLAIR
# 1	240	110	115	115	255	125
2	180	135	95	265	270	70
3	210	155	95	250	195	110
4	140	105	185	180	210	120
5	150	150	90	195	210	270
6	125	140	95		230	160
7	200	160			240	110
8	190					95
9	275					150
10	185					100
11	165					125
12	160					85
13	305					
14	290					

Table 6.--Total Number of Wild Areas Identified, Field-Checked and Recommended by County.

COUNTY	# of Wild Area Sites Interpreted from Aerial Imagery	# of Wild Area Sites Field-Checked	# of Sites Recommended for Wild Area Consideration
Allegan	14	7	4
Bay	7	4	4
Branch	6	3	3
Ionia	5	3	3
Livingston	7	4	4
St. Clair	12	6	4
Total	51	27	22

Upon completion of the imagery interpretation phase of the study, a field checking procedure was initiated to: 1) assess interpretation accuracy; 2) insure that all criteria received proper consideration; 3) verify that the grading scheme is an equitable measure of a site's wild area desirability; and 4) identify additional characteristics from an on-ground perspective such as off-site quality and general aesthetics. Due to time constraints, it was agreed that only half of the sites in each county (those having the higher point values) would be visited (see Table 5). A tabulation of the number of wild areas field checked and those subsequently recommended for DNR designation consideration by the Remote Sensing Project are listed in Table 6.

A summary report of the project was prepared and presented to the Wilderness and Natural Areas Advisory Board along with county maps showing potential wild area locations (example, Fig. 2), and site maps of each potential wild area (example, Fig. 3). The immediate Board response was to recommend a further review of the sites identified for possible dedication and also to look into the possibility of having additional counties inventoried on a contract basis. Presently a cost analysis is being prepared for the DNR.

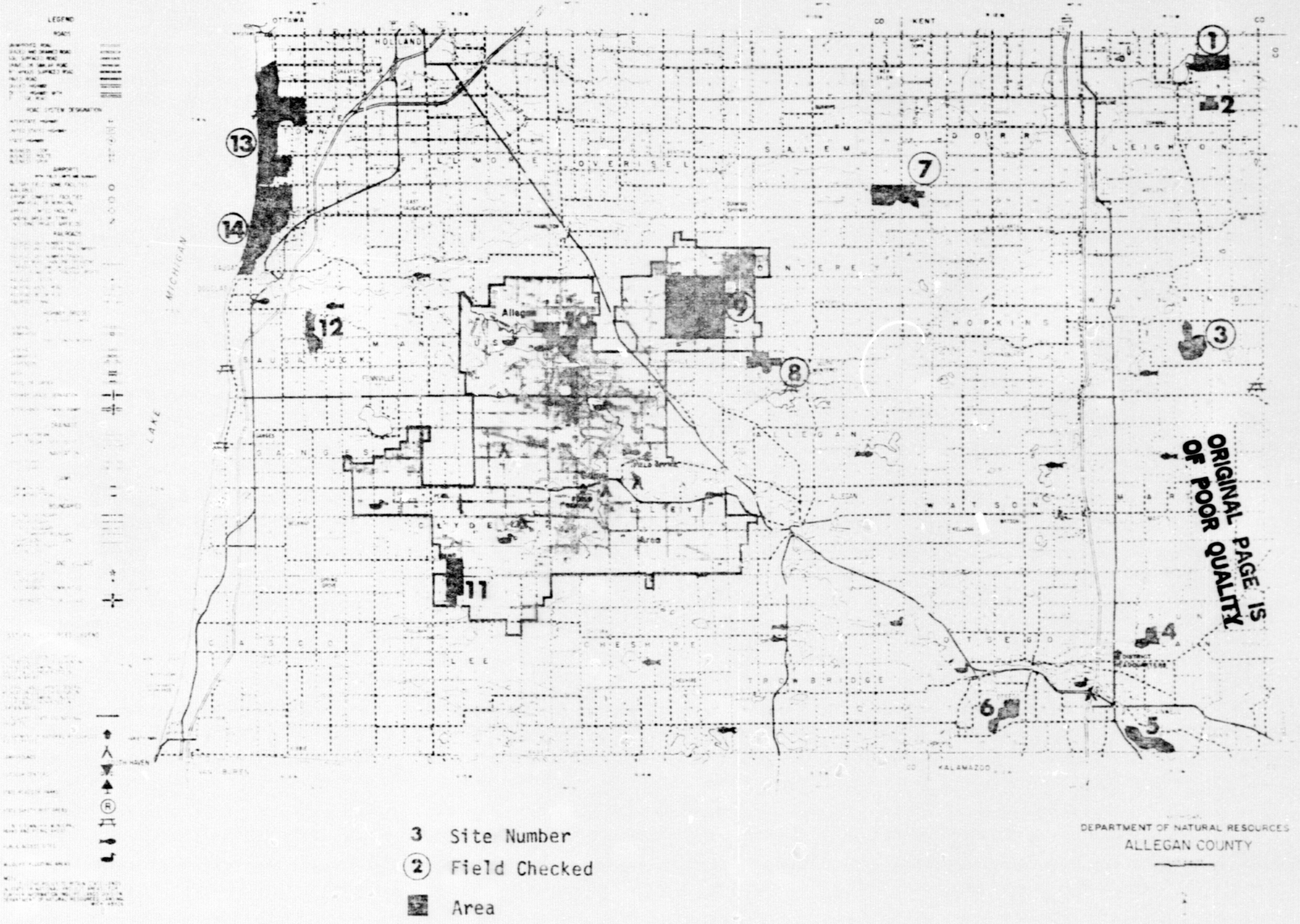


Figure 2.-- Potential Wild Areas.

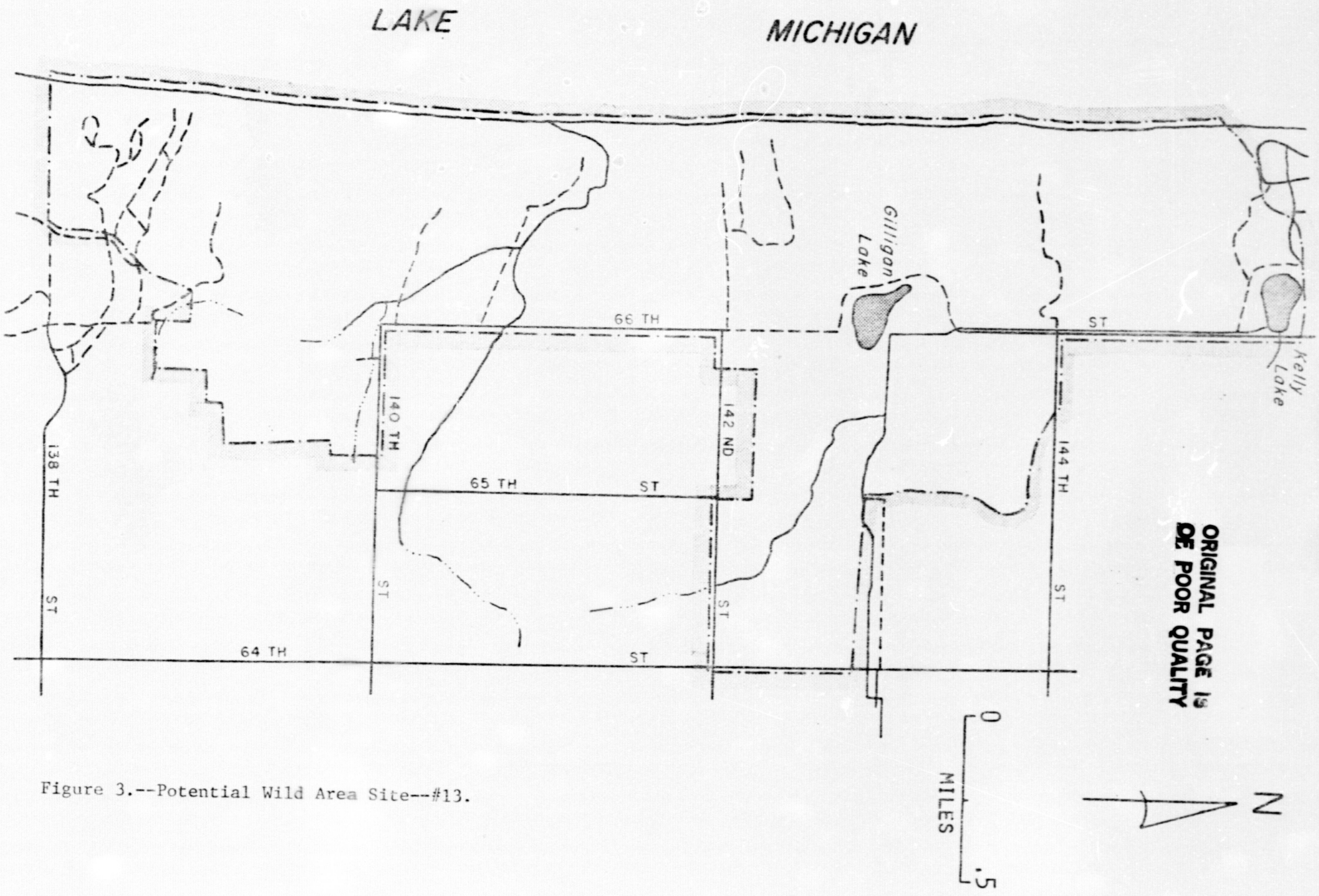


Figure 3.--Potential Wild Area Site--#13.

A3. Identification of Wood Energy Resources in Central Michigan

Dow Corning Corporation
Box 1592, MAIL 009
Midland, Michigan 48640

Morbark Industries, Inc.
Box 1000
Winn, Michigan 48896

Wolverine Electric Cooperative
302 South Warren Street
Big Rapids, Michigan 49307

Consumers Power Company
212 West Michigan Avenue
Jackson, Michigan 49201

The task of meeting energy needs is particularly important in Michigan, considering its dependence on outside sources of energy (Michigan presently produces only about four percent of its energy requirements). Renewable resources, particularly wood biomass, are being viewed as a highly desirable alternative energy source. While fossil fuels are relatively scarce in Michigan, forests are widely distributed in the state (about half of Michigan's land area is forested). Developments in using wood as a "direct-burn" energy source have progressed to a stage where it is now viewed as technically feasible and cost-effective.

The Dow Corning Corporation of Midland, Michigan and a cooperative venture by Wolverine Electric Cooperative (a publicly-owned electric generation and transmission cooperative), Morbark Industries, Inc. (a forest products firm which manufactures wood-harvesting equipment), and Consumers Power Company (a privately-owned electric and gas utility) are presently planning to build wood-burning generating plants in the mid-Michigan area. There is a lack of information on the extent, availability, and location of non-commercial timber resources (standing tree residues, over-stocked stands, logging residues, sites in need of conversion, etc.) which will be

used in these power plants. Therefore, both groups have requested assistance from the Remote Sensing Project in acquiring information on available wood energy resources from remote sensing.

The consortium of corporations (Wolverine Electric, Morbark Industries, and Consumers Power) conducted a feasibility study (in press) to: 1) determine the adequacy of the wood fuel base; 2) compare three potential plant locations; and 3) establish various engineering and regulatory procedures. Project investigators analyzed a variety of remote sensing products in order to determine the tonnage of the forest biomass and to compare supply estimations for the three potential sites.

A map summarizing the distribution of forest land in the study area is provided in Figure 4. Forest distribution was derived from the depiction of woodland on the U.S. Geological Survey (USGS) 1:250,000 map series as provided by the Office of Land Resource Programs, Michigan Department of Natural Resources (MDNR). Also included on the map are the three proposed plant sites with a line indicating a 50-mile radius from each site (the maximum distance that is considered economically feasible to haul wood chips). Forest data as depicted on Figure 4 and ownership information shown on MDNR county maps were geocoded and placed on a computer file. A computer routine then calculated the acres of forest land, by ownership, for specified radii (10, 20, 30, 40 and 50 miles) from each proposed plant site. The results are shown in Table 7. Based on this information, environmental data and the location of electrical transmission facilities, the consortium selected Hersey as the proposed site for their demonstration waste-wood generating plant.

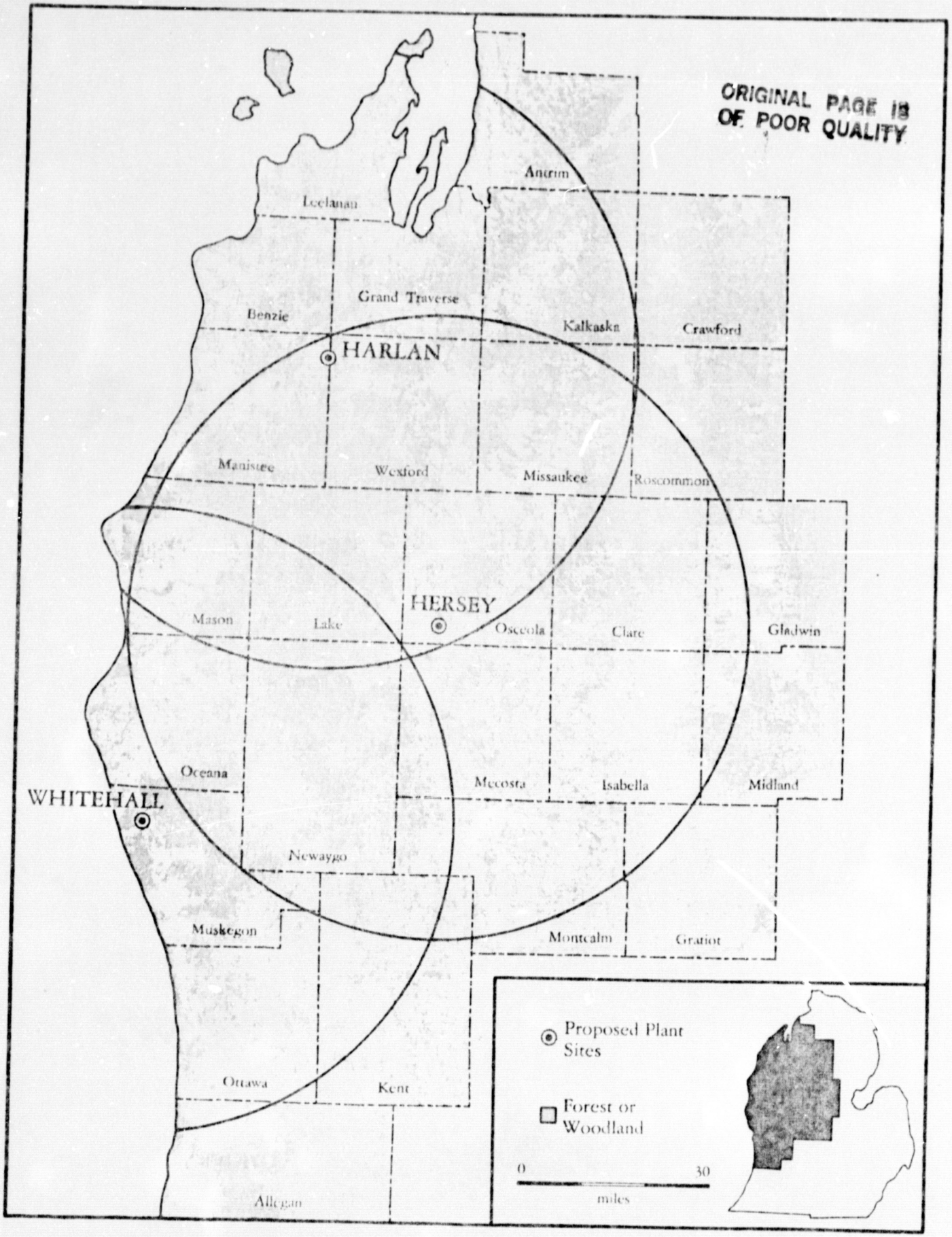


Figure 4.--Forest Distribution.

Table 7.--Acres of Forest Land by Site.

HARLAN

Radius (miles)	Acres of Forest Land				% of Area Forested
	Federal	State	Private	Total	
10	16640	33920	48640	99200	49.3
20	112000	85120	224640	421760	52.4
30	221440	182400	441600	845440	46.7
40	281600	284800	684160	1250560	38.9
50	355840	440320	973440	1769600	35.2

HERSEY

Radius (miles)	Acres of Forest Land				% of Area Forested
	Federal	State	Private	Total	
10	-0-	11520	20480	32000	15.9
20	33920	50560	227200	311680	38.7
30	224000	96000	524800	844800	46.7
40	364160	170880	879360	1414400	44.0
50	432000	370560	1266560	2069120	41.0

WHITEHALL

Radius (miles)	Acres of Forest Land				% of Area Forested
	Federal	State	Private	Total	
10	8960	1280	68480	78720	39.1
20	30080	8320	155520	193920	24.1
30	62080	10240	229760	302080	16.7
40	149120	12800	377600	539520	16.8
50	225920	30080	528640	784640	15.6

After selection of the Hersey site, the consortium requested the MSU Remote Sensing Project to provide them with more detailed biomass figures for a six-county area surrounding the site. Acreage data for four of the counties (Lake, Newaygo, Osceola and Mecosta) were compiled from the forest land management and inventory data service maintained by the West Michigan Regional Planning Commission (WMRPC). Forest cover-type information for the four counties was originally interpreted from medium-scale (1:33,000) color-infrared aerial photography. Forest lands were categorized into nine cover types, four size classes and four stocking levels. This effort was a continuation of the Mason County Forest Inventory conducted by the Remote Sensing Project.

Forest cover information for Clare and Isabella Counties was derived from analysis of LANDSAT satellite data. A density analysis, using a Spatial Data Datacolor Image Enhancement System, was performed on separate LANDSAT bands. Band 6 was analyzed to determine the presence (acreage) of water in a county and was subtracted from the acreage estimate of forest land and water derived from Band 5. Preliminary comparisons with NASA high-altitude RB-57 photographs indicate the forest acreage estimates to be better than 90 percent accurate.

In order to determine what the tonnage of the standing live waste and the surplus annual growth might be, it was necessary to estimate the total biomass of the forest land. This was accomplished by sampling biomass plots on representative forest cover types. Sample plots were set up by a Consumers Power Company forestry team, and harvested and weighed by a Morbark Whole-Tree Harvesting System. The per-acre tonnage of biomass,

as derived from these sample plots, was then applied to a net acreage of forest land which had been derived from remote sensing analysis. Table 8 compares the tonnages as derived from the ground cruise and weight tables with actual harvested tonnages.

TABLE 8.--Summary of Predicted vs Actual Tonnages for Selected Ground Plots.

Plot No./Type	Predicted T/A	Harvested T/A	% Error (of prediction)
1/06	90.2	92.1	-2
3/Pr6	128.9	133.5	-3
4/05	93.7	97.8	-4
6+7/04	50.1	49.6	+1
9/Pr6	125.3	126.4	+1
10/Ps3	14.0	26.6	-47
11/Pj6	164.8	132.7	+24

Applying the tonnages from Table 8, total biomass for sample forest plots, for the six-county study area, are presented in Table 9.

TABLE 9.--Biomass of Sample Forest Types.

Forest Type	BIOMASS (tons) Lake	Newaygo	Osceola	Mecosta	Total
04	621,591	710,318	29,008	35,922	1,396,839
05	3,812,840	3,566,784	127,807	260,673	7,768,104
06	4,313,184	3,481,900	231,543	859,425	8,886,052
Pr6	622,329	303,817	418,023	304,204	1,648,373
Pj6	1,939,202	495,389	5,109	20,765	2,460,465
Ps3	--	--	7,294	--	7,294
Total	11,309,146	8,558,208	818,784	1,480,989	22,167,127

Upon completion of the feasibility study, including the MSU remote sensing analysis, the consortium has determined that a waste wood-fired plant with a gross output of 25 megawatts is both technically and economically feasible subject to regulatory approvals and financing arrangements. If permits and approvals can be obtained without inordinate delay, the plant could be in commercial operation in 1983.

It is the stated intention of the consortium that "the plant will be used to gather operating experience, to evaluate equipment, to demonstrate environmental compatibility, to develop appropriate forest management practices, and to foster overall public acceptance of a technology that could lead to the serial production of similar units throughout the forest lands of Michigan." Because of the unique developmental aspects of this project, the MSU Remote Sensing Project is continuing to work with the consortium on developing remote sensing techniques which will provide a major input to the biomass supply program for a wood-fired plant.

A4. Highway Corridor Selection

Citizens Concerned About I-69
5965 Austin Way
Grand Ledge, Michigan 48837

The Michigan Department of State Highways and Transportation (MDSHT) is currently in the final hearing stage concerning the selection of a corridor for the I-69 highway extension in central Michigan: from the town of Charlotte to the city of Lansing. A corridor extending north from Charlotte and then east to Lansing has been proposed by the MDSHT. Although this corridor had been tentatively approved, a group of citizens within Eaton County have organized to advocate the selection of another corridor and this has been supported by the Eaton County Planning Commission. In response to this action, a review of the corridor selection process was ordered by the Governor of the State.

Two major issues have emerged in discussions regarding corridor selection:

1. Will the MDSHT corridor lead to an unacceptable loss of prime farmland?
2. What environmental effects will alternative corridors have on wetlands in this part of Eaton County?

In order to prepare their case for an alternative corridor, the Citizens Concerned About I-69 requested a land cover inventory for the four townships in northeast Eaton County that were in question. Using NASA high-altitude color-infrared imagery, 21 categories of land cover were inter-

preted and subsequently transferred to a 1:24,000 mylar base map supplied by the Tri-County Regional Planning Commission. The three wetland categories identified were color coded on a paper copy of the map prepared from the mylar base. The map was used to support the citizens group argument for an alternative corridor, however, the review procedure confirmed the MDSHT corridor and the citizens group has now filed a suit in order to further challenge the MDSHT proposal. It is possible the map will be used as documentary evidence in this case.

A5. The Impact of Pipeline Construction on Stream and Wetland Environments

Michigan Public Service Commission
6545 Mercantile Way
Lansing, Michigan 48910

In connection with their jurisdiction over pipelines, the Michigan Public Service Commission (MPSC) is charged with assessing the environmental impact of gas and oil pipeline construction on wetlands and stream crossings in northern Michigan. The Remote Sensing Project is conducting a demonstration project to show that drainage alteration and vegetation damage associated with pipeline construction can be monitored with temporal aerial photography.

In 1977, field investigators recorded present conditions at wetland and stream rights-of-way (ROWs) noting vegetation damage, invasion of new species and drainage conditions, particularly standing water within 50 feet of the ROW. But since the sites were not evaluated prior to construction, the cause of any damage observed could not be pinpointed, and recommendations to improve future routing and construction methods were difficult to make.

Since repetitive aerial photography may allow both pre- and post-construction vegetation and drainage conditions to be mapped, MPSC approached the MSU Project for assistance. Photo interpretation is also likely to be less expensive than field investigation and such conditions as ponding of water upstream or in the ROW, vegetation change, windthrow and dieback should be detectable on medium-scale photography.

Within the study area (Fig. 5), black-and-white panchromatic photographs at scales of 1:20,000 and 1:15,840 are available, with coverage dating back to 1938. In addition, 1973 and 1977-78 color-infrared photographs provide recent records of the pipeline sites. These sources combine to give adequate pre- and post-pipeline photo coverage for each site, and documentation of selected ROWs is on-going.

In the first phase of the project, a site in northwest Wexford County (Fig. 6) was studied. The vegetation cover map prepared from a 1973 photograph shows pre-pipeline conditions, with healthy vegetation and no apparent standing water (Fig. 7); but Figure 8 is the same site in 1977 with ponding upstream from the ROW and accompanying vegetation damage following construction. The company responsible for construction has subsequently taken the following corrective actions.

A construction crew was brought in to ditch across the pipeline causeway to reinstate the surface flow across the swamp and lower the impounded area. At the same time, the crew cut the stems of trees which had windthrown so that the stumps would fall back in place. The pipeline company, and personnel from the MPSC, will check the wetland crossing in the early summer of 1980 to see how effective these efforts have been.

Project personnel are currently involved with additional site interpretation and documentation of ROWs to fully evaluate the potential for remote sensing detection of vegetation damage and change, drainage alteration, and damage associated with off-road vehicle use.

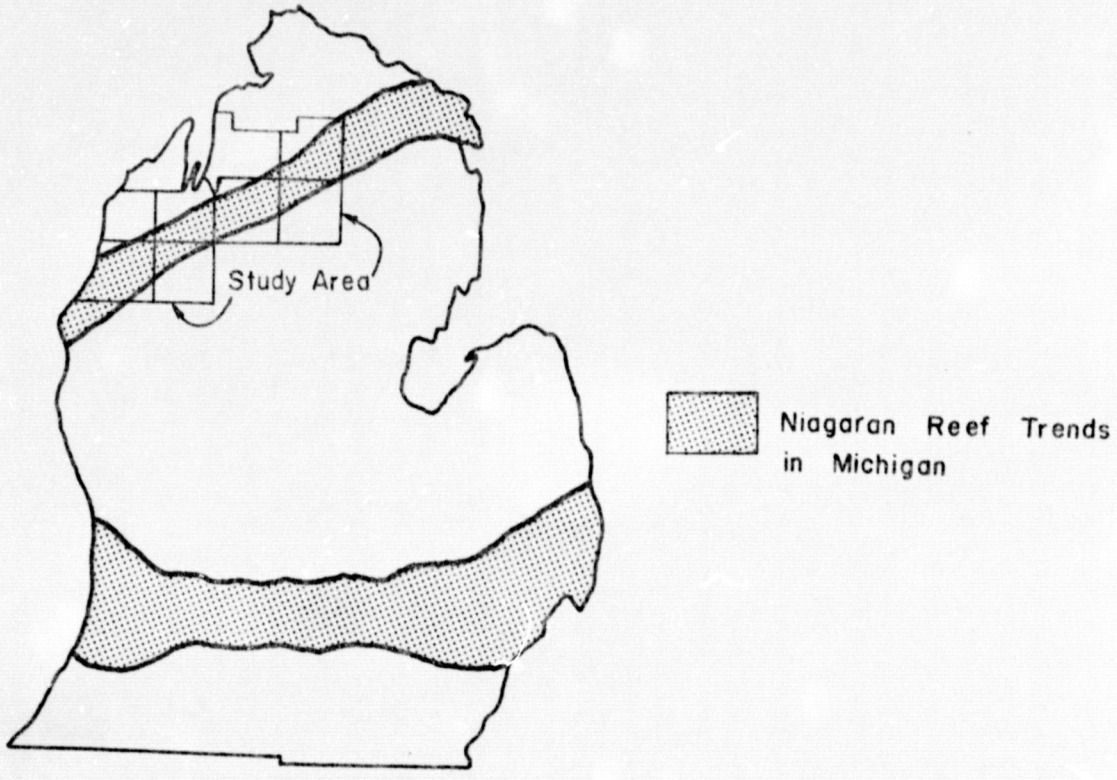


Figure 5.--Pipeline Construction Study Area.

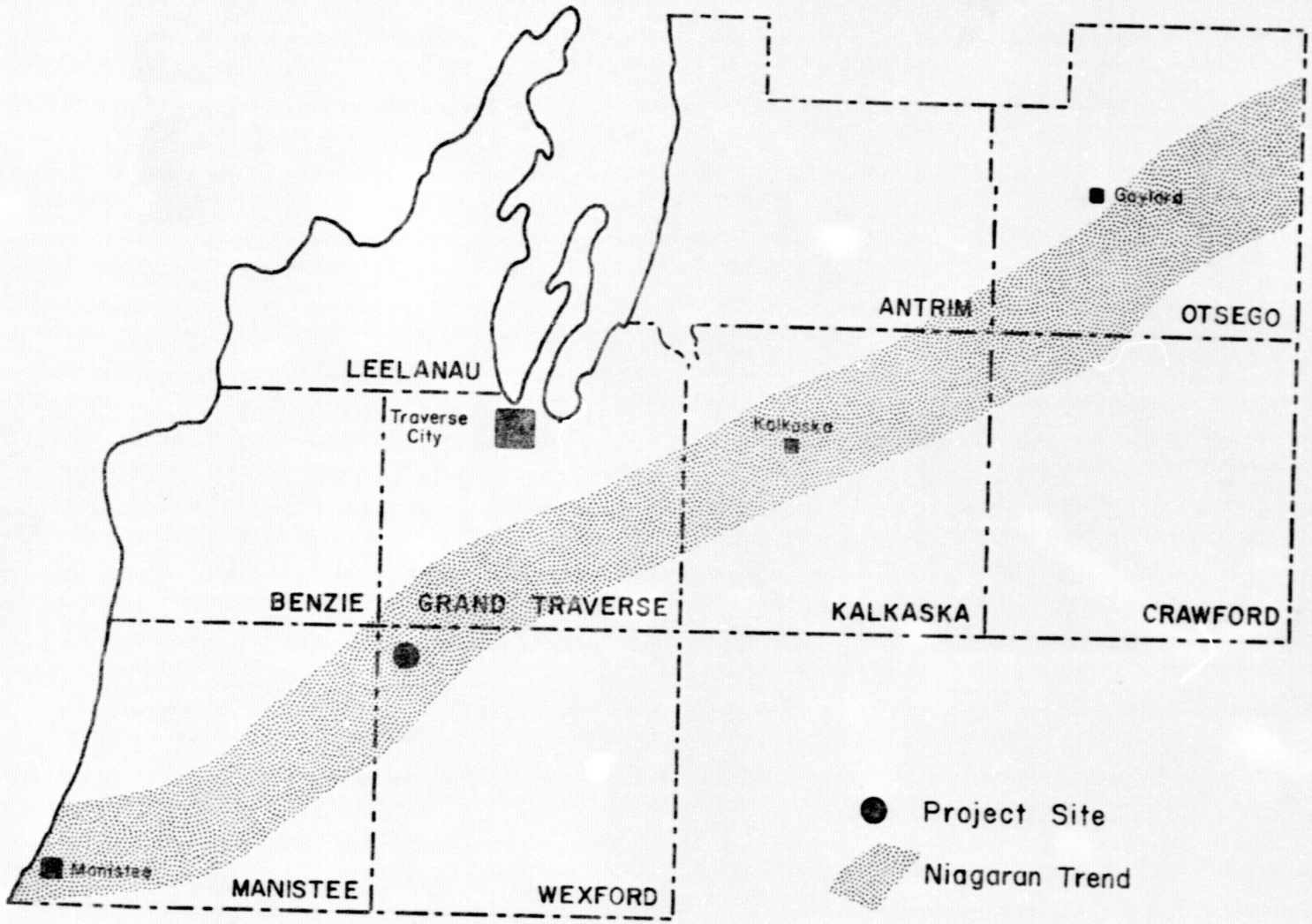
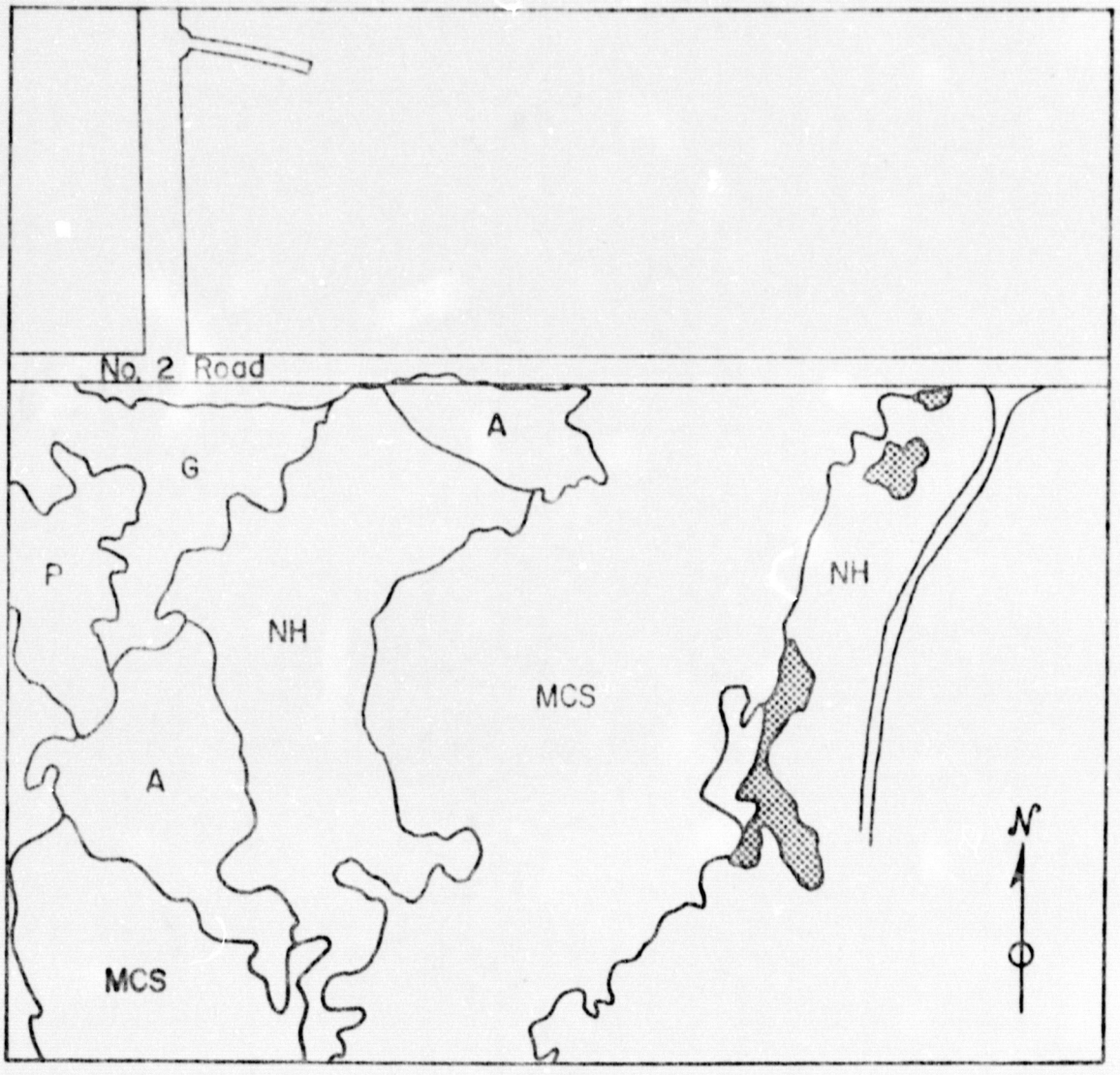


Figure 6.--Location of Project Site in Northwest Wexford County, Michigan.

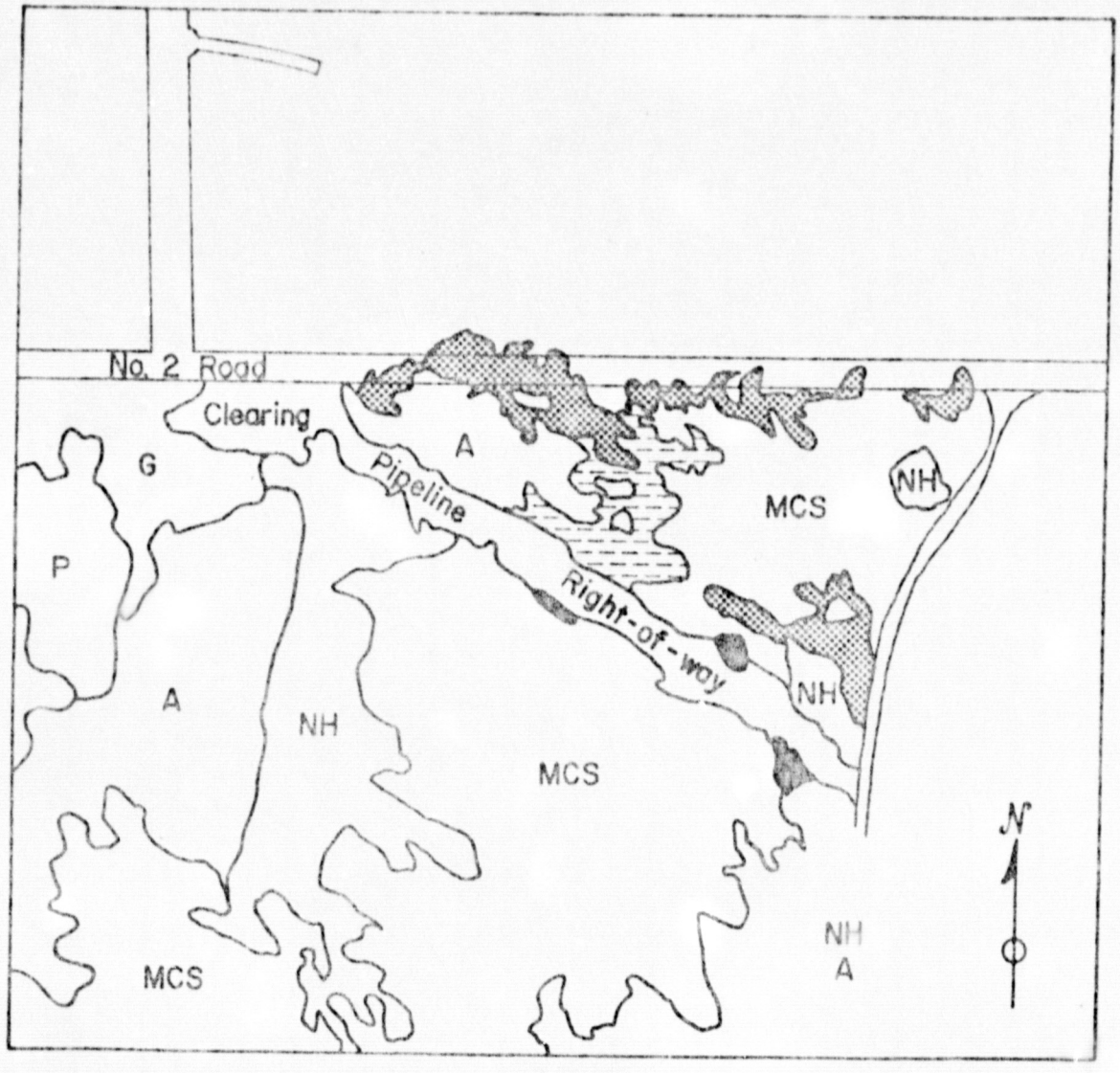


1 : 2000
Scale

A	Aspen
G	Grass
MCS	Mixed Conifer Swamp
NH	Northern Hardwoods
P	Pine

Shadows

Figure 7.--Pre-Pipeline Vegetation Cover-Type Map.



1 : 2000
Scale

A	Aspen		Windthrow
G	Grass		Dieback and Ponding
MCS	Mixed Conifer Swamp		Shadows
NH	Northern Hardwoods		
P	Pine		

Figure 8.--Post-Pipeline Vegetation Cover-Type Map.

B. USER SERVICES

Conducting research applications understandably generates demands for further information by users. As agency knowledge and expertise in remote sensing materials and methods develop, the need for review, instruction and updating becomes unavoidable. Project personnel routinely provide consultation on relevant aspects of imagery usage, issue illustrative materials and offer guidance to foster further application engagements by current and prospective users.

In these ways the MSU Project staff served as a reference service for an increasing number of public and private organizations. This kind of a service function involves providing NASA-generated imagery, training in the use of equipment, giving other general technical assistance, and directing inquirers to appropriate sources of further materials and information (books, articles, conference proceedings, manufacturers' catalogs, symposia, workshops, etc.).

More specifically, user services, among a larger checklist, commonly include such assistance activities as: 1) problem identification; 2) data source identification; 3) data classification procedures; 4) identification of decisions that need to be made (policy and action choices); 5) determining data efficiencies to get at the policy and action choices; 6) assistance in identifying available imagery; 7) assistance in acquiring available imagery and equipment; 8) providing estimates of cost for conducting particular studies; 9) imagery interpretation training; 10) merging remotely-sensed data with other natural and cultural resource information (e.g. ground truth).

Any combination of such assistance activities produces varying scopes and intensities of primary instruction for selected agency personnel, thereby making them aware of the capabilities of remote sensing for day-to-day and long-term needs.

Other than these kinds of on-going activities of serving users during this reporting period, two major events occurred and are significant developments in progress which deserve special mention.

The latter development is not really a "user service," but is of great potential for substantially extending and strengthening the scope and versatility of service to the people of Michigan. This action is that of seeking University recognition of the Remote Sensing Project as an official entity to be known as a Center for Remote Sensing.

The two major events referred to are concerned with: 1) the initiation of training workshops for Cooperative Extension Service personnel around the State (all costs paid for by the CES, other than some personnel time); and 2) major participation in a conference on applications of cartography and remote sensing.

B1. Institutionalization of the Remote Sensing Project

Michigan State University was among the first universities to experiment with the use of remote sensing imagery for dealing with issues of man's use of land and its many related resources. From such tentative beginnings in the mid-1960's came a major grant from the National Aeronautics and Space Administration (NASA) in late 1971 for explorations in uses of remote sensing for land use policy formulation and programs of implementing actions. Over this brief span of 15 years, MSU has developed a substantial competence in scientific personnel, facilities, and equipment. This growth has been incremental, based on ad hoc endeavors with specific allocations of financial support from grants and contracts . . . all from sources outside the University.

These increments of growth have been drawn together since 1971 in an unofficial collaborative organization, self-titled as the "Remote Sensing Project" (RSP), made up of faculty scientists and staff from a diversity of disciplines from nine departments/schools distributed among four colleges. The nature of the Project's mission was determined by the commitment of the original proposal and grant from NASA, namely to provide public and private agencies in Michigan essential information derived from sensor imagery which can assist them in resolving issues and needs, and interpreting and analyzing such information so that more effective management of economic and environmental resources may be achieved.

As stated in previous progress reports, the faculty and staff participants recognized that the variety and magnitude of engagements and the

increasing variety and scale of financial support were growing to such dimensions that this harvest of continuing commitments and achievements needed to be protected and strengthened by being drawn together into a recognized institutionalized structure. Accordingly, the faculty investigators and research staff of the MSU Remote Sensing Project conducted a series of demonstration conferences for department chairmen, school directors, deans, directors of the Agricultural Experiment Station and the Cooperative Extension Service, the Vice-President for Research, and the Provost to inform them of the organization and productivity of the RSP to point out strengths of this ad hoc collective activity, and to make clear the multiple vulnerabilities which can stem from the many constraints and handicaps under which the Project has to operate.

At each session, the concept of an official, university-acknowledged "center" was emphasized which, to be successful, would have to operate under a consortium of four (or more) college deans and the director of the Agricultural Experiment Station; would have relative autonomy as a specific administrative unit; and would be granted a core budget for continuing support of a permanent function.

These sessions culminated in a summit meeting on August 10, 1978, between the Principal Investigators, the RSP Budget Officer, two deans, the Vice-President for Research, the Provost, and some department/school chairmen. This session resulted in favorable endorsement of the concept and its many features. Strong encouragement was given for proceeding with the preparation and submittal of a formal petition.

During the fall term period, the faculty investigators and staff principals labored to produce a consensus of objectives, organization,

and strategies. This stage was achieved, and, as of this reporting date (February 1979), a full statement of petition has been prepared and submitted to the nine participating department/school chairmen for critical review. The petition is now being reviewed informally with the deans and others and will be shortly submitted for official action when our senior colleagues so advise. All reactions expressed indicate favorable consideration.

B2. Cooperative Extension Service Workshops

As reported in the preceding Status Report (June 1977 - November 1977), arrangements have been made so that personnel from the Remote Sensing Project can work closely with the Michigan Cooperative Extension Service (CES). This link enables the Project to utilize CES knowledge of current and emerging problems within the state that may benefit from a remote sensing input and gives the CES a powerful tool to call upon in their response to agricultural and natural resource concerns of local agencies and groups. Each County Extension Director received a copy of the Guide to Aerial Imagery of Michigan in February 1978 and with it a questionnaire which was directed toward identifying the type of involvement that would be of greatest utility. There was a 39 percent response to the questionnaire and of this group, 80 percent felt that some sort of a one-day workshop on remote sensing would be of value.

We have subsequently initiated a remote sensing program through the auspices of the District Extension Leader for Resource Development in southwestern Michigan. Four session have already been undertaken for key personnel from county and regional agencies invited by county extension directors. The sessions have met with considerable success and approval, and arrangements are in hand for sessions in other regional planning areas of Michigan.

B3. Applications of Cartography and Remote Sensing Conference

A one-day conference was organized in cooperation with the Center for Cartographic Research and Spatial Analysis and the Kellogg Center for Continuing Education at Michigan State University. Its purpose was to provide pertinent information on newer techniques and recent developments in the fields of remote sensing and cartography (see program) to personnel from county, regional and state planning agencies in Michigan. Eighty-seven participants registered for the conference. A questionnaire was completed by 58 of the participants, all of whom found the remote sensing session worthwhile. Sixty-five percent of the respondents would be interested in a further remote sensing workshop.

This conference introduced remote sensing to a new clientele with whom our contacts had previously been very limited.

Conference on Cartography and Remote Sensing

Purpose of the Conference

Most agencies involved in land use, transportation, recreation, agriculture, housing, or resource planning make use of maps or remotely-sensed imagery. These graphic tools are widely used for information collection and recording, data analysis and interpretation, and the display of information to other agencies or to the public.

The purpose of this conference is to provide useful information on newer techniques and recent developments in the fields of cartography and remote sensing. Hopefully participants will gain a understanding of research applications to problems encountered in the gathering and display of information.

The conference will include:

informative presentations with many illustrations on the application of current research findings and "state of the art" by university personnel involved in cartography and remote sensing

display tables on map production techniques and materials, remote sensing techniques and materials, and the production of the *Atlas of Michigan*

packets of materials including remote sensing data sources, guides to further information in cartography and remote sensing, computer mapping software summaries, bibliographies and references on current research, and sources for production materials and equipment

an opportunity for individual users of maps and remote sensing to discuss common problems and experiences with others in similar fields

Funds and support for this conference are provided in part by:

College of Social Science, MSU, Gwen Andrew, Dean

Department of Geography, MSU, Lawrence M. Sommers, Chairman

Kueffel and Esser Company, Morristown, New Jersey

NASA Remote Sensing Project, MSU, William R. Enslin, Director

Department of Resource Development, MSU, Raymond D. Vlasin, Chairman

Continuing Education Service, MSU

Conference Organizers:
Dr. Richard E. Groop and Dr. Richard M. Smith, Department of Geography, MSU

Program

8:30-9:00 a.m. **Registration, Kellogg Center Lobby**

Morning Session: Remote Sensing - Room 103

9:00 **Opening Remarks**
Dr. Dieter Brunnschweiler, Professor of Geography

9:15 **Introduction to Remote Sensing and Resource Inventory Techniques**
types, characteristics, and sources of aerial imagry; inventory procedures; interpretation and mapping techniques; data analysis and display; limitations; and costs
William R. Enslin, Director
Richard Hill-Rowley, Assistant Director
Stephen E. Tilmann, Information System Specialist
Remote Sensing Project, MSU

10:15 Coffee - Room 103

10:30 **Applications of Remotely-Sensed Data in Michigan**
land cover/use inventories; improving local on-land action programs; implementing environmental legislation; agricultural assessment procedures; and summary of MSU capabilities
William R. Enslin
Richard Hill-Rowley
Stephen E. Tilmann

11:30 Lunch - Red Cedar Room

Afternoon Session: Cartography - Room 103

12:45 **Opening Remarks**
Dr. Jack Williams, Associate Professor
Department of Geography, MSU

1:00 **Mapmaking: Ten Common Mistakes and Some Suggested Remedies**
thematic and "working" maps; map hierarchy; pattern problems; undergeneralization; unstandardized data; computer map symbol problems; and cartographers vs. draftsmen

Dr. Richard M. Smith, Assistant Professor
Department of Geography and Coordinator, Center for Cartographic Research and Spatial Analysis, MSU

1:45 **Recent Research in Cartography: Implications for Mapmakers**
value and use of research in cartography; symbol perception studies; map reader search patterns; interactive computer graphics; movie, a dynamic computer map of traffic accidents in Washtenaw County

Dr. Harold Moellering, Assistant Professor
Department of Geography, Ohio State University

2:30 Coffee - Room 103

2:45 **Computer Mapping at Michigan State**
applications of computer mapping; data structures; computer mapping software packages; and summary of MSU capabilities

Dr. Robert Wittick, Associate Professor
Department of Geography and Computer Institute for Social Science Research, MSU

3:30 **Closing Remarks**
Dr. Lawrence M. Sommers, Professor and Chairman
Department of Geography, MSU
Editor, *Atlas of Michigan*

4:00 Optional Tour: Center for Cartographic Research and Spatial Analysis, Olds Hall

C. CONTRACTUAL SERVICES

Just as the steady flow of Project demonstration applications has generated an increasing amount of user services, it has also created a contractual demand for information derived from remotely-sensed data. Most agencies now have a rudimentary understanding of remote sensing techniques, however, they cannot afford to employ and retain staff with photo interpretation and cartographic skills to meet periodic needs. Neither do they have the necessary equipment to derive the essential information from remotely-sensed data.

With more improved LANDSAT imagery becoming commonly available and used, considerable expertise is needed for both "manual" (visual) and digital interpretation. Very few private and public organizations have capabilities of deriving information from this source and they must therefore depend on contractual services. LANDSAT 3's improved image resolution and quality increases this dependency and has already resulted in the MSU Project being called upon repeatedly to provide such contractual services when a request does not meet the established criteria for a NASA-funded demonstration cited in Section A, "Research Applications." Such services have been performed for a variety of private organizations, federal, state, regional, and local government agencies and for foreign nations. All expenditures are cost-reimbursable unless some part of the service involves an innovative demonstration application. In this situation, the agency pays for all costs other than

the innovative application research. All of the following contractual activities reported in the three following units were performed on a cost-reimbursable basis.

C1. Comprehensive Resource Inventory and Evaluation System (CRIES)

U.S. Department of Agriculture
Economics, Statistics, and Cooperatives Service
Room 305, Manly Miles Building
1405 South Harrison Road
East Lansing, Michigan 48823

The CRIES project continued throughout this reporting period. CRIES is a cooperative program between Michigan State University and the Economic Research Service of the U.S. Department of Agriculture and is funded by the Agency for International Development. The objective of the project is to create the technical skills and institutional capabilities of developing countries to conduct agricultural planning and other resource management studies. The project is a multi-agency and multi-disciplinary effort. The Remote Sensing Project at MSU is contributing technical skills and services in two major project areas: remote sensing and geographic information system development.

During the past year, several reports were issued. Two of the reports explain the CRIES geographic mapping system and were used in a workshop on the mechanics of geocoding that was held in the Dominican Republic. The workshop was part of a program that included the installation of the Resource Analysis Program (RAP) onto an IBM 370/115 computer, and a training seminar on how to use RAP. A week-long training session was also held in East Lansing for the Dominican counterparts (to the CRIES staff). This was an on-site workshop on the remote sensing activities and the mapping system in the Dominican Republic.

In January of 1978, the Agency for International Development (AID) and the U.S. Department of Agriculture held an 18-month review of the CRIES project. The outcome of the session was very favorable. While at the meeting, the CRIES staff became acquainted with Dr. Ernest Hardy's (a member of the evaluation team) computerized diazo process to enhance LANDSAT scenes, and this process will be incorporated into future LANDSAT interpretation procedures.

Part of the CRIES effort is to test and evaluate different techniques which could be used for collecting land use data. One such test was a comparison of LANDSAT data that had been interpreted both visually and digitally for a province in the Dominican Republic. The purpose of the test was to evaluate the compatibility of the data obtained from each of the methods. Results show that, overall, only 65 percent of the information was classified similarly. However, when comparing just the agricultural land use categories, there was only a 10 percent discrepancy.

CRIES has also been involved in a study which compared the costs of manual and digital processing of geographic information. Personnel at the Remote Sensing Project did the manual geocoding while Bendix Aerospace Systems Division (Ann Arbor, Michigan) did the digital processing. Initial results indicate similar costs, but the level of technology involved with manual geocoding is more easily transferred to developing countries.

Another geocoding activity that took place during the period was encoding the Cantone map for Costa Rica into the geographic information system. The land area totals were in close agreement with published national

totals; a discrepancy of only 40 km^2 was found out of a total area of 51,100 km^2.

During the summer, a sugar cane rust infection occurred in a majority of the sugar cane fields of the Dominican Republic. The rust primarily affected cane variety B-4362 which accounts for nearly two-thirds of the total planted cane acreage of the State Sugar Council (CEA). The Dominican government requested that the Remote Sensing Project, through the CRIES project, undertake a survey using light-plane aerial photography in order to help evaluate the severity of the problem. A photographic team was dispatched to the country and a research program initiated. A team of Dominican specialists visited East Lansing to assist in the photographic evaluation. The preliminary results indicated cane stress is readily detectable in large-scale color-infrared film. The study continued to the end of the reporting period.

In conjunction with a contract extension from AID Washington, a complete land cover/use map of the Dominican Republic was begun. The map is being developed by visual interpretation of LANDSAT imagery. A request was made to NASA in order to obtain up-to-date coverage. The mission is scheduled for December 1978 and January 1979.

Contract work was begun in Syria under the CRIES project. The Remote Sensing Project is responsible for developing a land cover/use map from visual interpretation of LANDSAT and to develop the geographic information base. No formal activity was started before November 1978.

C2. Inventory of Sand Mining Sites in Michigan's High-Priority Sand Dune Areas

Geology Division
Michigan Department of Natural Resources
Stevens T. Mason Building
Lansing, Michigan 48909

The Sand Dune Protection and Management Act (PA 222, 1976) requires the development of sand mining monitoring procedures to be used by the enforcing agency. The Geology Division of the DNR has contracted with the Remote Sensing Project to assist them in the development and implementation of these procedures. The work has been broken down into four objectives that have to be addressed: 1) determination of the optimal remote sensing techniques and information system structure to periodically monitor sand mining activities; 2) acquisition of aerial photography for sand mining operations in the high-priority sand dune areas of Michigan; 3) preparation of an inventory of sand mining activities in the high-priority sand dune areas of Michigan utilizing the information generated in objective one; and 4) development of a sand mining surveillance procedure manual.

The initial work evaluating remote sensing techniques for monitoring of sand mining activities has been completed (see Table 10). Medium- and high-altitude photography is currently considered the best data source for the provision of general land cover/use information, required to evaluate environmental impacts on a bi-annual basis. Low-altitude photography of 1:15,000 scale is recommended for acquisition of information

TABLE 10--Utility of Various Imaging Platforms and Scales for the Extraction of Mined Lands Information.

MINED LANDS INFORMATION	PLATFORM AND IMAGE SCALE						
	AIRCRAFT					SATELLITE	
	LARGE SCALE 1:10,000	1:20,000	MEDIUM SCALE 1:30,000	1:40,000	SMALL SCALE 1:60,000	1:120,000	SKYLAB 1:500,000	LANDSAT 1:1,000,000
MINING FEATURES:								
MINING OPERATION ≥ 10 ACRES	———	———	———	———	- - -	.....		
MINING OPERATION < 10 ACRES	———	———	———	- - -	- - -	.....		
NON-COMMERCIAL Borrow Pits (1-2 acres)	———	- - -	- - -	.....	.....	.....		
RECLAMATION FEATURES:								
PERCENT VEGETATION COVER	———	———	———	- - -	- - -	.....		
SURFACE ROUGHNESS	———	———	———	- - -	- - -	.....		
SLOPE PERCENTAGE	———	- - -	- - -	.....	.....	.....		
ENVIRONMENTAL FEATURES:								
LAND USE/COVER LEVEL I	———	———	———	———	- - -	- - -	- - -	- - -
LAND USE/COVER LEVEL II	———	———	———	- - -	- - -	.....	.....	.....
LAND USE/COVER LEVEL III	———	———	- - -	- - -	.....	.....	.....	.....
VEGETATION STRESS	———	———	———	- - -	- - -	.....	.....	.....
LANDSLIDES	———	———	———	- - -	- - -	.....	.....	.....
EROSION ASSESSMENT	———	- - -	- - -	.....	.....	.....	.....	.....
WATER TURBIDITY	———	———	———	- - -	- - -	.....	.....	.....
GROUND WATER DEPTH ANALYSIS	———	———	- - -	- - -	.....	.....	.....	.....
ECOSYSTEM EVALUATION	———	- - -	- - -	.....	.....	.....	.....	.....

LEGEND:
——— VERY USEFUL, HIGH ACCURACY LEVEL, EFFICIENT DATA SOURCE
- - - - USEFUL WITH MODERATE RESTRICTION, REQUIRES HIGHLY SKILLED IMAGE ANALYSTS
..... LIMITED USEFULNESS, REQUIRES ADVANCED ANALYSIS TECHNIQUES

regarding the status of sand mining sites on a semi-annual basis. Low-level systems with flexible operational characteristics (stand-by basis, local applications) currently provide the best guarantee for a sufficient and qualitatively acceptable information collection at a low cost, and a sound basis for the legal enforcement of the Act.

In response to the second objective, color, near-vertical 70mm photography at 1:15,000 scale was acquired of all mining sites as identified from an initial interpretation of existing aerial photography in order to update mining status, areal extent and the land cover/use information of immediately adjacent areas.

Land cover/use information (Table 11) for areas adjacent to sand mining sites is also being mapped on clear acetate overlays which will be positioned on mylar base maps of topographic sheets by means of registration pins. The sand mining sites will be coded for easy cross-referencing with compiled 1:15,000 color, 70mm photobases. The mining site coding scheme will consist of a unique indicator for the designated area, a sequence number for unique flight planning purposes, and U.T.M. coordinates to the nearest 100 meters, indicating the approximate location of the center of the mining site (e.g. A1-7-753/628). An acetate overlay with a 100 x 100 meter grid based on U.T.M. coordinates (1:24,000) will be provided to aid in future referencing.

A procedure for sand mining surveillance has been established (Fig 9) and a report has been prepared which outlines the monitoring and inventory procedures for sand mining operations in Michigan (see reference 78).

TABLE 11.--Land Cover/Use Categories Used for the Sand Dune/Mining Inventory (modified after Michigan Land Cover/Use Classification System, 1975; Division of Land Resource Programs, Michigan Department of Natural Resources).

LAND COVER/USE CLASSIFICATION SYSTEM FOR THE MICHIGAN SAND DUNE/MINING INVENTORY PROJECT

Interpretation based on predominant Land Cover/Use type of 1 ha (100 x 100 m) (approx. 2.5 acres)

11 Residential

- 111 Medium and High Density
- 112 Low Density (less than 1 D.U./acre)

12 Commercial, Services and Institutional

13 Industrial

14 Transportation, Communication and Utilities

17 Extractive, Surface Mining

- 171 Active Status, Spring 1978
- 172 Inactive Status, Spring 1978
- 173 Sand Storage

18 Cemetery

19 Recreational

- 191 Public
- 192 Private

21 Cultivated Cropland and Improved Pasture

22 Specialty Crops (orchards, bushfruits, vineyards, ornamental horticulture, Christmass tree farms, and other specialty crops)

31 Herbaceous Ground Cover

32 Shrub Ground Cover

41 Deciduous Forest

42 Coniferous Forest

43 Mixed Forest

44 Dune Grasses

5 Water

61 Forested Wetlands

62 Non-Forested Wetlands (brush swamp)

63 Vegetated Open Water

7 Barren

- 72 Beaches
- 73 Sand Other Than Beaches
- 74 Transitional Areas

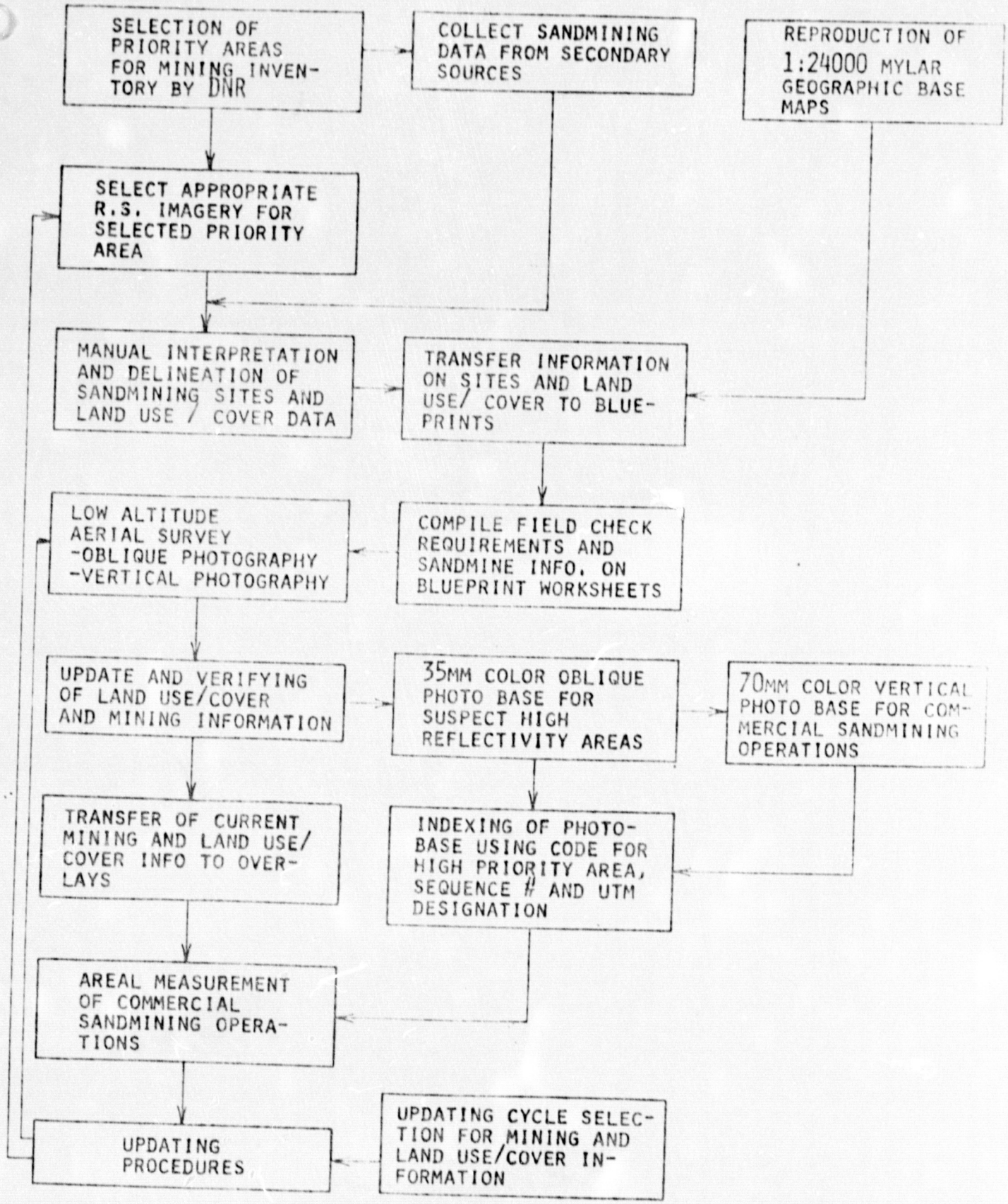


Figure 9.--Flowchart Outlining the Procedures for the Michigan Sand Dune Mining Inventory.

C3. Sand Dune Classification and Inventory of Michigan's High-Priority Sand Dune Areas

Geology Division
Michigan Department of Natural Resources
Stevens T. Mason Building
Lansing, Michigan 48909

The Sand Dune Protection and Management Act (PA 222, 1976) requires the development of a dune classification system for Michigan and an associated inventory of dune types, specifically the delineation of barrier dune complexes along the Great Lakes shoreline in the state. The Michigan Department of Natural Resources is the agency designated to implement this legislation, and has contracted with the Remote Sensing Project to complete a series of work elements to assist them in this process.

A dune classification has been developed (see Fig. 10) based on dune form, orientation, relative relief, arrangement and the relationship of the dune complex to the underlying formation. The scheme is objective in that it relies on morphologic and geometric patterns which can be interpreted from large-scale aerial imagery. No attempt is made to incorporate genetic aspects into the classification.

Currently, a two-mile strip extending along 90 miles of Lake Michigan shoreline is being classified according to the classification scheme. Panchromatic 1:20,000 ASCS photography is used for the delineation of the following features:

1. Boundaries of the individual dune complex, with appropriate identifying codes (a fractional code indicator developed

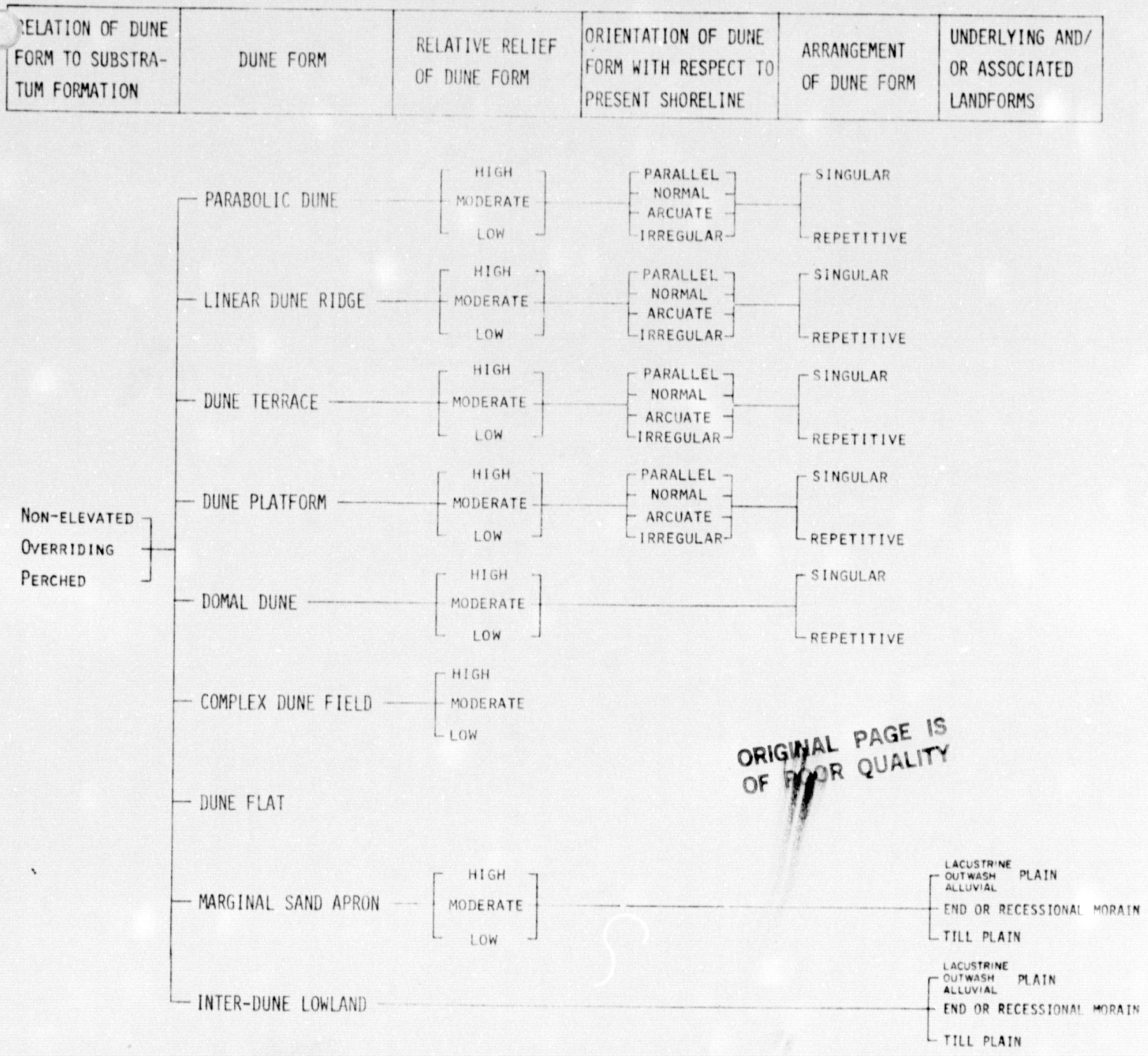


Figure 10.--DUNE MORPHOLOGY CLASSIFICATION OF THE LAKE MICHIGAN SHORE

WILLIAM R. BUCKLER
with the assistance of
DIETER H. BRUNNSCHWEILER

REMOTE SENSING PROJECT

MICHIGAN STATE UNIVERSITY

1978

from the classification scheme)

2. Barrier dune boundary
3. Discernible dune crest lines
4. Notable bluff crests and shorelines of older, higher, glacial lakes
5. Present land/water boundaries
6. Beach zone
7. Selected spot elevations
8. Location indicators

The preliminary working definition of a barrier dune boundary is: "that landward boundary line of the dune complex which displays the greatest relative relief within the two-mile-wide Lake Michigan shore zone."

The delineated dune inventory information is being transferred to 1:24,000-scale acetate overlays compatible with the land cover/use and surface mining information that is being compiled under a separate contractual arrangement with the Geology Division of the DNR (see Section C2). Together these sources will facilitate the review of future sand mining permit applications as required by law.

C4. Shiawassee National Wildlife Refuge Vegetation Inventory

Johnson & Anderson, Inc.
P.O. Box 1166
2300 Dixie Highway
Pontiac, Michigan 48056

U.S. Fish and Wildlife Service
Federal Building
Fort Snelling
Twin Cities, Minnesota 55111

Johnson & Anderson, Inc. (consulting engineers), under contract from the U.S. Fish and Wildlife Service, subcontracted with the Remote Sensing Project for the provision of a vegetation inventory of the Shiawassee National Wildlife Refuge.

The wildlife refuge is an area 14.9 square miles (38.7 sq. km.) in size located in Saginaw County approximately five miles south of the city of Saginaw. Situated in an area of prime agricultural land at the confluence of four major rivers (the Cass, Flint, Shiawassee, and Titabawassee), the wildlife refuge is located entirely within the 100-year floodplain.

The inventory entailed identifying 18 land cover types (mainly lowland hardwoods (36%), wetlands (17%), and cropland (22%)) to a minimum 2.5-acre type size from 1:60,000 NASA high-altitude color-infrared imagery taken on May 13, 1975. The classification system employed is given in Table 12. This data was supplemented by growing season (full leaf-out) information obtained from similar scale imagery taken on July 1, 1975.

Johnson & Anderson were provided with a mylar map of the vegetation inventory at a scale of 1:24,000 and area calculations for each cover type for use in preparing a master plan and subsequent environmental assessments for refuge development projects.

TABLE 12.--Land Cover Classification Used in the Shiawassee National Wildlife Refuge Inventory.

Map Symbol	Vegetation Type
SM	Shallow Marsh
CM	Cattail Marsh
[illegible]1	Deep Marsh
SS	Shrub Swamp
G	Grass
GB	Grass-Brush
SB	Shrub-Brush
LH	Lowland Hardwoods
LHS	Lowland Hardwoods (saplings)
SSDLH	Shrub Swamp with Dead Lowland Hardwoods
GCWS	Grass with Cottonwood Seedlings
CW	Cottonwood
CWS	Cottonwood (saplings)
CC	Cultivated Cropland
MS	Moist Soil Unit
BP	Barrow Pit
X	Building Site

C5. Agricultural-Use Valuation

Eaton County Equalization Department
1045 Independence Boulevard
Charlotte, Michigan 48813

In previous Progress Reports (June 1976 - November 1976 and December 1976 - May 1977) we reported on the application of a technique for agricultural-use valuation for test areas in Eaton County, Michigan. The technique is adapted from a procedure developed by the Michigan Tax Commission and utilizes a soils map, a slope map, a land use map, and information obtained from simple market surveys of the area.

The procedure has been developed into a new phase (AGVALUE) of the Resource Analysis Program (RAP), a computer-based information system developed at the Project. This phase uses soil and slope data from soil surveys to generate estimated yields for the crops typically produced in the study area. These yields are then used to generate a "soil productivity index," where the prime, most productive soils, have an index of 100 and soils not suited for farming are given a rating of zero. The technique is not applicable to organic soils (muck and peat) since agricultural production on these soils greatly depends upon structural improvement (e.g. drainage and erosion control) and is often of a specialty nature. The soil productivity index is a linear estimate of the income-generating potential of the soil, i.e., soils rated 50 are one-half as productive as soils rated 100.

Base land values must be developed through a local market survey. The survey examines recent sales in order to establish the current market

value of soils with a particular productivity index, usually 100, or prime soils. Such a market survey naturally takes into account local conditions, market pressures on farmland, costs of production, and other vital aspects of land values. In some instances, land value may be estimated for more than one land use. For instance, cultivated cropland usually has an inherently different market value than does pasture land.

Current market values for the parcels contained in the mapping system are determined by multiplying the appropriate base land value by the appropriate soil productivity index. Specific, non-agricultural land uses may be selectively deleted from the analysis. The resulting values, in units of dollars per acre or dollars per land parcel, may be displayed and summarized on a section-by-section basis (Fig. 11).

The utility of this system to the County Equalization Director was such that he assigned his own departmental funds for expansion to cover all of his county, and geocoding of the data for a 14-township area was completed in-house. These data were then key-punched and verified at MSU and used in the AGVALUE phase of the RAP program to generate desired map products. The services were provided on a cost-reimbursable basis.

The information is currently being used directly in four townships in conjunction with a reassessment which is taking place this year. Use of the maps is being integrated into regular office routine and are also used as a training tool in assessment procedures for township supervisors.

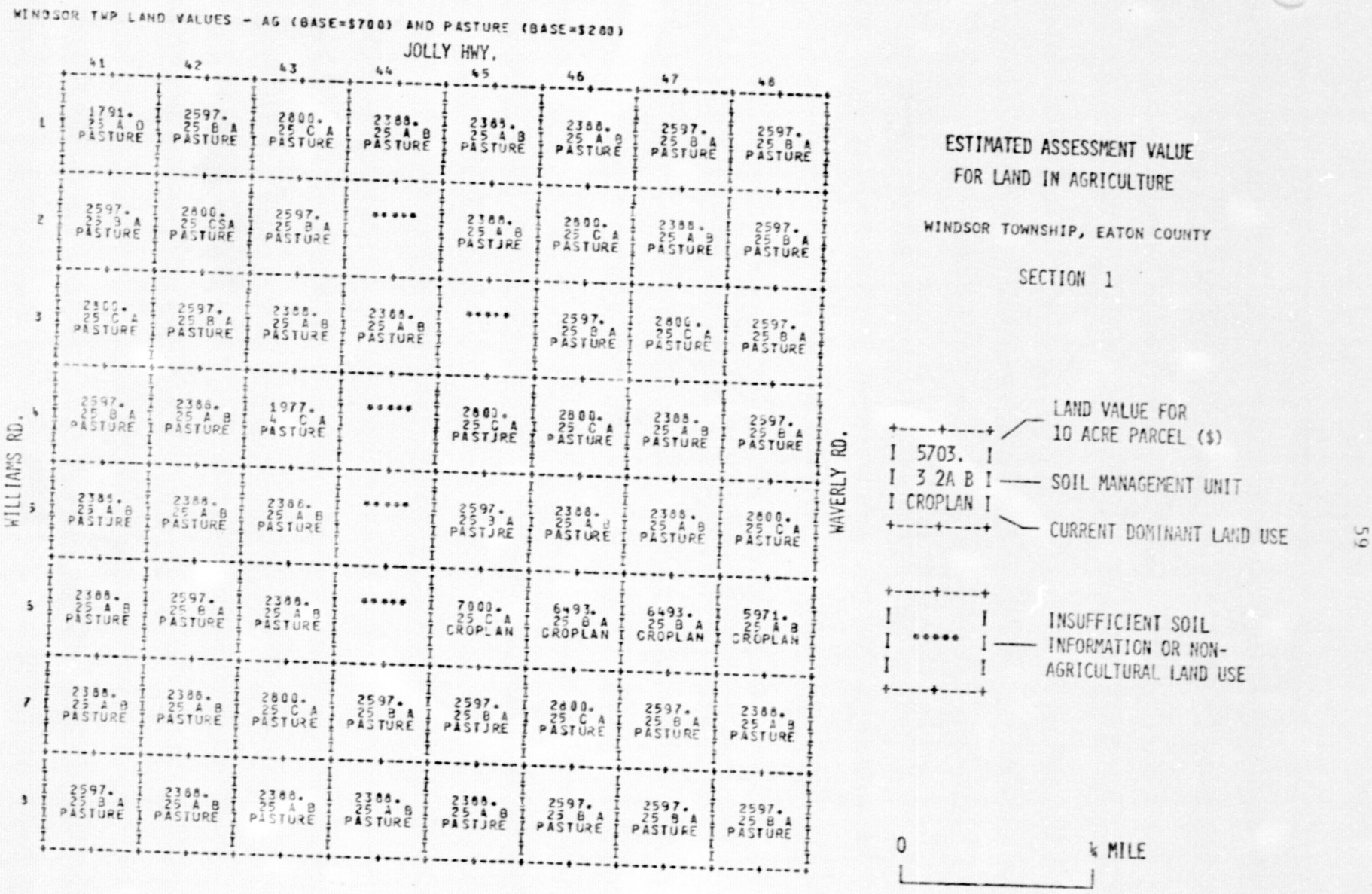


Figure 11.--A sample map for Section 1 of Windsor Township displays farmland value, dominant soil management unit, and current land use for each 10-acre parcel in the Section. The numbers along the border of the map indicate the row-column coordinate of the grid cells. In the Windsor Township study, agricultural land was assigned a base value of $700 and pasture was assigned a base value of $280.

Appendix

PUBLICATIONS and PRESENTATIONS

. . . . . of the Michigan State University Project

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1. "Investigation of Land Resource Use in Southeast Michigan." J.G. Ahl, M.G. Boylan, D.L. Mokma, W.L. Myers, S.W. Schar and R.D. Vlasin. Proceedings of the Eighth International Symposium on Remote Sensing of Environment. pp. 23-33. Environmental Research Institute of Michigan. Ann Arbor, Michigan. October 1972.

2. Remote Sensing in Michigan for Land Resource Management: Highway Impact Assessment. Environmental Research Institute of Michigan. Ann Arbor, Michigan. December 1972. 107 p.

3. Users Guide to High Altitude Imagery of Michigan. Mark C. Sullivan and Stephen W. Schar. Michigan State University. East Lansing, Michigan April 1973. 39 p.

4. Proposed Land Use Classification System. Project for the Use of Remote Sensing in Land Use Policy Formulation. Michigan State University. East Lansing, Michigan. July 1973. 26 p.

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6. Image Interpretation for a Multi-Level Land Use Classification System. Mark C. Sullivan and Gary Higgs. Michigan State University. East Lansing, Michigan. September 1973. 35 p.

7. The Use of Color Infrared Photography for Wetlands Mapping: With Special Reference to Shoreline and Waterfowl Habitat Assessment. William R. Enslin. Michigan State University. East Lansing, Michigan. October 1973. 33 p.

8. Upper Kalamazoo Watershed Land Cover Inventory. Benjamin Richason III and William R. Enslin. Michigan State University. East Lansing, Michigan. October 1973. 39 p.

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14. "Operational Remote Sensing for Land Capability Analysis of Michigan." Myles G. Boylan and Stephen W. Schar. Presented at Michigan Academy of Science, Arts and Letters. Environmental Studies Section. Michigan State University. East Lansing, Michigan. March 1974.

15. "A Quick Procedure for Developing Environmental Planning Inventories in Michigan." Stephen W. Schar. Presented at Michigan Academy of Science, Arts and Letters. Environmental Studies Section. Michigan State University. East Lansing, Michigan, March 1974.

16. "Color-Infrared Airphotos as a Source of Forest Resource Data for Regional Information Systems: Putting Remote Sensing Technology to Work in Northwestern Michigan. William D. Hudson and Wayne Myers. Presented at Michigan Academy of Science, Arts and Letters. Environmental Studies Section. Michigan State University. East Lansing, Michigan. March 1974.

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